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the
Large
Hadron
Collider
project

LHC Project Document No.
LHC-BQ-ES-0001 draft

CERN Div./Group or Supplier/Contractor Document No.
AB/BDI

EDMS Document No.

Date: 2006-09-22

Functional Specification

DEFINITION OF THE SCOPE, BOUNDARIES AND SHARE OF RESPONSIBILITIES FOR THE LHC TUNE FEEDBACK TASK WITHIN THE US-LARP FRAMEWORK

Abstract

This specification defines the scope of the LHC tune feedback task within the US LHC Accelerator Research Programme (LARP), as well as the boundaries and share of responsibilities between CERN and its US partners.

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History of Changes

Rev. No.	***Date***	***Pages***	***Description of Changes***
1.0	2006-09-22	5	Creation of document

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1. INTRODUCTION

The US LHC Accelerator Research Program enables U.S. accelerator specialists to take an active and important role in the LHC accelerator during its commissioning and operations, and to be a major collaborator in LHC performance upgrades. In particular, LARP will support U.S. institutions in LHC commissioning activities and accelerator science, accelerator instrumentation and diagnostics, and superconducting magnet R&D to help bring the LHC on and up to luminosity quickly, to help establish robust operation, and to improve and upgrade LHC performance. Furthermore, the work performed will be at the technological frontier and will thereby improve the capabilities of the U.S. accelerator community in accelerator science and technology to more effectively operate our domestic accelerators and to position the U.S. to be able to lead in the development of the next generation of high-energy colliders.

The LARP goals are as follows:

Advance International Cooperation in High Energy Accelerators

- Advance High Energy Physics
- Help bring the LHC on and up to design performance quickly
- Improve LHC performance by advances in accelerator understanding and instrumentation
- Use LHC as a tool to gain deeper knowledge of accelerator science and technology
- Extend LHC as a frontier HEP instrument with a timely luminosity upgrade

Advance U.S. Accelerator Science and Technology

- Keep skills sharp by helping to commission the LHC
- Conduct forefront AP research and development
- Advance U.S. capabilities to improve the performance of our own machines
- Prepare U.S. scientists to design next generation colliders
- Develop technologies necessary for next generation colliders

2. SCOPE OF THE US-LARP TUNE FEEDBACK TASK

Instruments capable of tune, chromaticity and coupling measurements are crucial for efficient operation with intense beams in superconducting accelerators. They are particularly useful to help deal with dynamic effects during injection, at the beginning of the ramp and during the low beta squeeze. Automatic and robust measurement of the tune without adverse side effects is a challenging problem for hadron accelerators and is the focus of this R&D effort. With a reliable tune measurement, a feedback system can be implemented and tested in a straightforward way.

The US-LARP tune feedback task is to provide:

- *the necessary instruments for the continuous measurement of tune, chromaticity and coupling in a robust way, with minimal emittance blow-up in the LHC.*

These instruments shall be foreseen to allow for the rapid implementation of tune feedback in the LHC, and the possibility of subsequent chromaticity and coupling feedback.

3. CHOICE OF INSTRUMENTS

Research and development on sensitive, robust tune measurement systems has been underway for several years between CERN and its US collaborators, Brookhaven National Laboratory and Fermi National Accelerator Laboratory. The technology to be used for the LHC tune measurement system was presented and endorsed at a recent review of the tune feedback task by external US-LARP reviewers [1].

The tune measurement will be based on a direct diode detection (3D) system recently developed at CERN, a technique proven to be an order of magnitude more sensitive than the methods used in existing systems. This will be followed by a Base-Band Tune (BBQ) acquisition system integrated with a standard CERN instrumentation VME64x acquisition board (DAB64x).

The tune tracking algorithm will rely on a phase locked loop (PLL), which has been successfully used for many years at RHIC. In addition to tracking the tune, such a system can be used to measure the chromaticity in the presence of RF modulation and has recently been shown to be capable of providing continuous coupling measurements [2]. These algorithms will reside in an FPGA located on the DAB64x board.

Using this architecture continuous tune, chromaticity and coupling data will be available to LHC operations from an early stage, and will allow the implementation of feedback on any or all three of these parameters.

4. DEFINITION OF BOUNDARIES AND RESPONSIBILITIES

For the prototype system to be tested at RHIC,

CERN will provide:

- Direct Diode Detection analog front end modules
- NIM ADC acquisition cards
- DAB64x cards
- DAB control and acqusition mezzanines
- VME64x crate
- field programmable gate array code
- LabVIEW control program

BNL will provide:

- VME host computer
- Caen VME/USB interface
- NIM crate
- Support of and collaboration on FPGA code and LabVIEW control program
- test installation at RHIC, including a suitable pick-up, kicker and cabling
- necessary auxiliary instrumentation (oscilloscope, spectrum analyser etc.)
- beam tests at RHIC

FNAL will provide:

- continued R&D for various open issues

For the final four systems to be installed in the LHC (one per beam per plane),

CERN will provide:

- pick-ups and kickers
- cabling and associated infrastructure
- Direct Diode Detection modules
- BBQ front-end systems
- NIM ADC acquisition card and crates
- BBQ control mezzanines
- BBQ acquisition mezzanines
- DAB64x cards
- VME64x host computers
- VME64x crates
- necessary auxiliary instrumentation (oscilloscope, spectrum analyser etc.)
- application programs for PLL control and measurement displays
- necessary infrastructure for the real-time feedback of tune, chromaticity and coupling.

BNL will provide:

- collaboration on field programmable gate array code
- collaboration on LabVIEW control program
- collaboration with CERN on controls integration
- collaboration with CERN on application programming
- pre-beam and beam commissioning support

5. REFERENCES

[1] http://www.agsrhichome.bnl.gov/LARP/050404_Tune_Feedback/

[2] P. Cameron et al, "Simultaneous Tune and Coupling Feedback in RHIC, and Possible Implications for LHC Commissioning", available at http://www.rhichome.bnl.gov/AP/ap_notes/cad_ap_index.html